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ABSTRACT

Case studies of five French firms illustrate the impact of new work technologies on training. Liquid Corporation has embarked on changes in production technology in response to market needs. Four aspects of the change process are as follows: creating the climate for change, selecting operators, defining new training requirements, and training for new work technologies. At Computer Systems International, training is an integral part of management activities to keep employees who are involved in cutting-edge technology at the forefront of knowledge. The company faces the need to improve the cost effectiveness of training. The experience of Avionics, a leading manufacturer of aviation equipment, illustrates the initial stages of adaptation of training policies and practices to the uncertainties associated with technological change. Two phases in Avionics' organizational development are preparing workers to accept eventual, yet unclear changes and restructuring individual careers to cope with future uncertainties. At Control Panel Corporation, automation coupled with infinitely small margins of tolerance and very small room for inefficiency explain the pervasive upskilling of its labor force. At Intelligent Pots, Inc., training has preceded automation. Probably more important than formal training are the informal mechanisms of learning through participation and exchange of ideas. (12 references) (YLB)

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The impact of new work technologies on training

by João Batista Araujo e Oliveira

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Discussion Paper No. 81

The impact of new work technologies on training
Five case studies in French industry

by João Batista Araujo e Oliveira

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Preface

The cases presented in this publication are part of an ongoing study on the impact of new work technologies on training. The visits to the industries analysed were made possible through the collaboration of the Chamber of Commerce of Haute Savoie, in France, through ETUDOC - the Centre d'Etudes de Documentation et de Formation. The author is very grateful to Mr. Bernard Vésin, Director of ETUDOC and to the firms visited.

The opinions expressed here are not an endorsement or sanction of the policies and practices described and are the author's sole responsibility. The names - as well as some characteristics of the firms - have been slightly changed to avoid identification without sacrificing objectivity. We are not interested in specific firms, but in the trends observed in firms adopting new work technologies.

This paper is part of a series of studies conducted by the author for the International Labour Office (ILO).

As this is part of work in progress, the author would welcome comments and feedback from readers.

Only a few characteristics were extracted for each firm to illustrate points of interest.

Contents

Preface iii

I. Liquid corporation 1

A. Introduction 1

B. Reorganising the work 2

C. Changing the glass bottling line 2

1. Creating the climate for change 3

2. Selecting operators 3

3. Defining new training requirements 3

4. Training for new work technologies 4

5. Learning from experience 5

II. Computer Systems International 9

A. The company 9

B. The plant and the real work 10

C. A culture of training 11

1. The Personal Development Plan 11

2. Basic skills 12

D. Scenarios and challenges 12

III. Coping with the uncertainties of high-tech: The case of Avionics 15

A. Introduction 15

B. Phase I: Anticipating change 16

1. A stranger named Boeing 17

C. Phase II: from training to career planning 18

D. Discussion 19

1. Coping with uncertainty 19

2. The nature of basic technological skills 19

3. Investing in training: under- or over- investment? 20

4. Organisational learning 21

IV. Control Panel Corporation 25

A. The factory 25

B. The process of automating 25

C. The central challenges of production 26

D. Quality: from one per cent to 1,000 per million 26

E. Upskilling the entire workforce 27

V. Intelligent Pots, Inc.

A. The business of Intelligent Pots, Inc. 31

B. The automation process 31

C. Automation at Intelligent Pots 32

1. Slow, progressive and steady rhythm of implementation 32

2. The management of uncertainty 32

3. Changes in work organisation 33

D. Developing human resources 34

1. Incentives for learning 35

2. Changes in recruitment practices 36

Annex I. Technology literacy curriculum at Avionics 37

References 39

I. Liquid corporation

A. Introduction

Liquid Corp. has been operating for over 30 years, and has maintained its leadership position in both domestic and foreign markets. The company's major product is mineral water. Supply of good quality water is no problem, and the firm has been operating on an expanding buyers' market over the last decade. It enjoys a distinctive niche in specific market segments - children, sports and health - that it carefully nurtures.

In the mid-eighties the firm started to implement changes in its products, marketing strategies and production technologies, to cope with the increasingly sophisticated demand of some segments of its market, while at the same time facing increasing competition. It also perceived the need to become more aggressive to maintain its domestic market, and to secure larger exports.

Liquid Corp. responded to these challenges by increasing production, expanding the range of products, improving quality control, and repackaging its major product in a number of different sizes, shapes and types of containers. A few new products were incorporated, but the traditional mineral water still represents over 80 per cent of its operations. Even though the properties of the water it sells are an essential pre-requisite for success, a critical challenge is how to package and to market its products to make them attractive to its various clientele.

The change in production technology seems to have entered Liquid Corp. as a response to market needs - rather than as a technical requirement of production itself. Markets seem to have affected work technology in two major ways.

First, market segmentation requires varied packaging, which in turn required differentiation of production lines, containers and packaging methods. It also entails the mastery of fairly complex technological processes associated with producing and packaging the new plastic, P.V.C. and E.L.T. (polyethylene) containers.

Second, market regulations in some countries limit the types of containers acceptable, thus leading to constant updating, improvement and change, as well as to additional differentiation of product lines, depending on the importing countries.

Thus, environmental concerns - which heavily affect the market image in this business - also constrain the technological choices concerning materials used for packaging. Besides the traditional glass container, the new plastic and polyethylene containers were also introduced, each one bringing with it additional technological variety and complexity. Glass is the cheapest and easiest container to handle in the bulkier segments of the domestic market - but is not cost-effective for foreign operations. PVC has some cost advantages, including the fact that it can be partially recycled, but is rated negatively by environmental legislation in some countries. ELT is pollution free, but is not recyclable.

Thus, it became imperative for Liquid Corp. to adopt new production technologies to cope with the growth of production, the increasing demand on quality of product and packaging as well as to allow an efficient operation based on state-of-the-art production technology. Substantial changes were progressively introduced in what has been a traditional, stable factory for many years.

B. Reorganising the work

Production was traditionally organised on tayloristic principles. Each operator was in charge of a machine performing a single task, or a group of operations in a production line. Operators were supervised by an experienced technician, totally familiar with the production process, and usually able to solve major technical problems. Both preventive and corrective maintenance were provided by the specialised maintenance crew. Few product lines existed, and the factory operated in three shifts. Very low mobility existed. Training was seldom necessary, and whatever was needed could be learned on the job, over long periods of time.

Workers came from neighbouring villages. They had a strong feeling of identity with the product - the water came from their village - and belonged to the local community. The water - and the company - was perceived by the workers as an integral part of community life. Thus, any changes that would disrupt firmly established expectations and work routines were not welcome.

Within this cultural context and tradition, new, more sophisticated, computerised or automated machines have been gradually introduced since the mid eighties. The sequence and nature of the production process remained the same: continuous flow, only rarely interrupted to change the type or size of the bottle. The major difference was that new machines often performed more tasks, thus reducing the number of production lines, and hence, the number of operators required. Different degrees of automation and integration of production operations still co-exist at the plant.

More often than not, new machines were accompanied by the introduction of new tasks and new work arrangements. Operators became increasingly involved with and responsible for first degree maintenance as well as for most quality control functions. These changes also affected the traditional role of the supervisors. For the new automated production lines, supervisors were asked to plan and to implement the reorganisation of the new production lines, and to assign functions to personnel. They were also explicitly made responsible for planning the training of the personnel under their responsibility. This was a critical task, considering the attitude towards change analysed above.

The next section illustrates the impact of automation by focusing on one production line, glass bottling. The analysis focuses on the operators, and on how the change process was implemented. Since implementation was gradual, subsequent production lines were reorganised on the basis of the experience accumulated.

C. Changing the glass bottling line

The initial changes in the glass bottling line were relatively limited. The containers remained the same, and automated machines were introduced to integrate the whole production process which was previously performed by sequential work lines where each machine and each operator performed one or a few functions in the bottling process.

Before the reorganisation took place, there were 50 operators in the glass bottling unit. New technologies, new machines, and new work arrangements required only 20 operators. Yet, production doubled. Thirty operators were to be made redundant.

A plan was made to select and train the new operators, as well as to re-allocate the workers made redundant to other tasks.

Four aspects of this process are analysed below:

- Creating the climate for change
- Selecting operators
- Defining new training requirements
- Training for new work technologies

1. Creating the climate for change

Any change that would threaten workers, workers' rights, definition or re-definition of tasks, disrupt established work patterns and small group relationships by reallocating personnel was likely to encounter resistance. Three key issues had to be negotiated with the workers and their unions. First, the redefinition of tasks had to be considered. Second, even though the nature of the job of the operators was unaltered, they would now have to perform many different tasks, for which they would need new skills: any real or perceived threat of unemployment would be fiercely resisted. Protection and guarantees against redundancy would become a potential issue. Third, despite the fact that some workers were willing or even preferred to accept simpler jobs in the short run to avoid unemployment or to avoid disrupting their social structures, this could become a potential problem affecting their motivation in the long run.

Liquid Corp. was in the fortunate position to avoid the unemployment issue: the firm had been expanding steadily for five years, and jobs for the non-selected operators could be easily found in other conventional production lines.

The second item on the agenda, redesigning the job, has also proved not to be a major problem. One reason is that the new jobs were not initially perceived as attractive by the operators: those jobs would disrupt their previous work patterns, social networks, and require training. With jobs guaranteed, and few incentives associated with the new functions, why bother? This lack of interest or apparent indifference by the great majority of operators became a problem for selection and training. But, at the same time, it contributed to facilitating negotiation with the employees: if they were not over-enthusiastic about the changes, they were equally not opposed to them. The next challenge consisted of motivating and selecting the new operators.

2. Selecting operators

Selecting the new operators turned out to be a complex and time consuming task. The average operators were 45 years old. Eleven of the 30 workers were over 50 years old. Most of the operators had over 20 years in the same firm and the same job. Job security and the maintenance of the social bond among colleagues seemed more attractive than working with new technologies.

Moreover, the very few opportunities for promotion which arose in the past were handled directly by management - workers had not needed to show any initiative. Why should they bother now? In the end, it was agreed that management would take the decisions, based on a number of criteria which included past performance, supervisor's opinions, personal interests and the results of an orientation session led by outside consultants.

In spite of all these efforts to inform and involve the workers, motivating them for receiving training and moving into the new production lines has proved to be a very difficult task. Training was initially intended for all, but in practice it was limited to the 20 chosen ones. Most of the other operators remained either as operators in other traditional production lines or were relocated to less complex jobs.

3. Defining new training requirements

Even though the nature of the new work arrangements was not entirely clear to all parties involved, there were some ideas about what the new tasks of the operators would be. No detailed task analysis could be performed before some experience with the new machines was obtained and evaluated. Consideration must be given to the fact that machines were new, work processes would be different, production would significantly increase, technologies were not entirely familiar.

Management and supervisors enjoyed a broad margin of discretion to divide the work between operations, maintenance and quality

control. This is an extremely critical observation, which helps to correctly understand the process of technology innovation. New automated production lines may lead to very different ways of deploying the workforce. The way work is actually allocated to different people depends not so much on the configuration of the machines as on social and human factors, such as management styles, level of training of the workforce, training budgets, implementation time, as well as on the attitudes and behaviour of workers and unions. Thus, up-skilling, de-skilling or multi-skilling depend much less on the machines and technologies and much more on the ways Liquid Corp. conceived and divided the tasks among supervisors, maintenance technicians and operators. There seems to be very little of the so-called technological imperative.

Nonetheless, management had some concrete ideas about what operators could and should do. The work of operators would require technical competencies, including diagnostic skills, problem solving, and performing basic maintenance chores. Most quality control activities could also be transferred to the line: that would require some basic knowledge of chemistry and mastery of quality control tools and techniques. New relationships with maintenance crews had to be developed, to ensure smooth and precise communications. It no longer suffices to stop the line and call the mechanic: now operators have to attempt to avoid problems before they happen; if they occur, the operators have to try and solve them; if a mechanic is required, the operator should be able to say what is wrong, or at least communicate hypotheses about the malfunctioning of the machine. Thus, operators need to acquire a number of intellectual and technical skills, develop a high capacity for attention and concentration, learn how and what to communicate with technicians and supervisors to prevent stoppages, minimise down time and speed up corrective interventions, and participate in finding and implementing the application corrections. To perform all these functions, the operators would require more than just a few specific techniques. Some basic technical knowledge about the machines and the functioning of the entire production line would also be required.

Management, however, was aware that once embarking on plant automation, innovation and change would become a way of life. New machines being introduced today would soon become obsolete. As a consequence, imparting knowledge and skills to operate these machines was not enough: operators needed to understand the logic of the production systems and the underlying functions that must be performed for production, regardless of the types of machines used.

This, therefore, was the nature of the training challenge Liquid Corp. had to overcome. At the time of implementing the change in the first production line, these needs were certainly not as clear as they seem in retrospect. But management already knew that new operators would need to be interested in learning, to know how to learn, to possess basic technical skills, to accept change as a fact of life, and to be willing and able to work cooperatively.

4. Training for new work technologies

The next problem was deciding where to start, and how. Motivation was not very high; workers were relatively old, and had been out of school for many years; most of them did not possess any technical background. For many years they had been involved in routine tasks and were not used to changes in the production line.

After considering alternative training strategies, it was decided to use a methodology called P.I.E.- Program of Instrumental Enrichment - developed by R. Feuerstein (Martin & Paravy, 1990). Even though management expectations about this programme were both very diffuse and very high, and mostly based on the opinions of managers of other firms, a simplified version was implemented - 40 hours over 10 weeks as opposed to the 120-160 hours usually recommended by the proponents of the methodology. The major objective of using this methodology was to prepare the workers to accept changes, and to facilitate their attitude

and intellectual skills towards further training (learning to learn).

P.I.E., like any programme which attempts to change behaviour, attitudes and develop cognitive strategies, is very hard to evaluate. Two major results, however, were observed by supervisors and managers, which facilitated the rest of the training programme: (1) an increase in self-confidence, and (2) an improved ability to work and solve problems in groups. Even though these two goals might seem trivial, only those familiar with the difficulties of dealing with older adults can appreciate their worth.

Program of Instrumental Enrichment

P.I.E. is an educational and training methodology developed by Prof. Reuven Feuerstein. It consists of a series of exercises and group discussions led by a moderator (mediator) focussing on 14 intellectual strategies, such as planning, organising, problem solving. The major assumption of the methodology is that human beings are capable of developing their intelligence (ability to learn). The full programme consists of over 14 blocks containing more than 500 possible exercises, and usually takes from 120 to 160 hours. To achieve major impact, the author recommends that P.I.E.be simultaneously used with other education or training courses, so that participants have an opportunity to transfer the cognitive abilities learned or re-learned during the programme P.I.E. is intensively used in industrial training in France, and to a smaller extent in other countries, such as Canada, Israel and the U.S. For additional references see Martin & Paravi (1990).

As mentioned in the box above, one of the characteristics of P.I.E. is that it must be simultaneously used with other content-oriented training, in order to promote the transfer of the newly acquired cognitive skills. In this case, the technical part of the training programme was totally performed on the job. Supervisors and maintenance crews were allocated to the new production lines six months before they started operating. The functions of this team included organising the work flow, establishing controls and division of labour, and training the new operators. During these six months, some maintenance specialists benefitted from training provided by the suppliers of the production tools at their own sites or by participating in the assembly of the new automated machines at Liquid Corp. The operators were trained by their supervisors or the maintenance crew as the machines were installed and tested.

Besides acquiring the specific skills necessary to operate the new machines, additional training was provided on the job, over the initial months of the new operation. For example, new quality control instruments were jointly designed by operators, maintenance crews, supervisors and quality control staff. Within a few months, over 80 per cent of these tasks were transferred directly to operators. Filling out the quality control forms, understanding their meaning and the logic behind them, discussing results and receiving feedback in the monthly quality improvement meetings became part of an ongoing training process.

5. Learning from experience

A major characteristic of the approach adopted by Liquid Corp. in introducing new work technology was the sequential method used in the implementation process. Learning

was thus accumulated from one production line to the next, so that continuous improvements could always be made and incorporated into operations. The major characteristics of this process are discussed below.

The work technology adopted by Liquid Corp. is based on state-of-the-art automated production techniques. Even though the production process is relatively simple - when compared with other chemical or manufacturing plants - many uncertainties arise. The changes in the overall staffing pattern were noticeable, with the incorporation of an increasing number of technicians and highly trained operators and a decreasing, although still large, number of unskilled workers.

Liquid Corp. seemed to benefit from its leadership position through favourable market conditions and less aggressive competitors to introduce changes in a relatively smooth way. Experience has shown that these changes can be very painful and complex, and in some cases negotiations with unions over worker conditions can delay the introduction of technology for over ten years (Bastos do Valle, 1989).

However necessary or beneficial as these external market conditions might have been, they were not sufficient. This case illustrates the benefits of a planned, negotiated, and carefully implemented process of change. A distinctive aspect of this process was the attention given to local, contextual factors, the most important of which was the understanding of the characteristics of the workforce, its motivations and its needs.

Yet, all the planning efforts did not necessarily yield positive results. For example, Liquid Corp. did not expect such indifference from workers towards new technology. Nor did it anticipate their lack of interest in training. Nor are employees - or the firm - happy about the de facto de-skilling of most of the former operators - even though they refused the opportunities for training and moving into the new automated lines. These are all facts of life - that have to be dealt with in the overall context of technological change. Such reactions cannot be simply ignored - or simply discarded as resistance to change.

In this case, the firm's willingness to understand the issue in its overall context, to spend the time to disseminate information, and to negotiate with the unions and the employees improved its ability to promote the intended changes in a relatively short period of time. Subsequently, introducing new work technologies in other units went much more smoothly - even though, in some cases, tougher approaches had to be used. For example, nowadays the firm is even more aggressive in challenging its workers, in creating imbalances, in provoking its workforce to take on new work responsibilities. To some extent, this reflects the firm's improved ability to deal with the issue. Not only did Liquid Corp. itself learn from the exercise, but it can now also show concrete examples of workers re-adapted to the new production lines. And it is also attempting to avoid the problems of de-motivation reflected by absenteeism and lower productivity of the workers who preferred to remain in the traditional production lines.

The use of P.I.E., in particular, taught the managers that workers can indeed be re-motivated to learn, and once re-motivated, they can perform adequately with new work technologies. Quality control is another case in point. The first work re-organisation maintained separate functions for quality control. The requirements of the technology and the interest of the new operators, however, quickly allowed most of the quality control functions to be passed on to the line. The same is now happening with maintenance.

On the basis of this successful experience, the firm decided to expand training in basic skills - including P.I.E. and other production oriented courses - to the entire workforce. This approach, however, is not without its problems. So far, the firm has been expanding and is able to offer new, challenging opportunities. But no one knows whether it will be able, in the future, to provide challenging jobs to the workers who are now being offered new training opportunities.

Liquid Corp. illustrates a plausible combination of using highly automated technologies and sophisticated marketing strategies to produce and sell a very prosaic product, such as water. But is it really prosaic? New clients require increasingly strict quality controls - Perrier's recall of millions of bottles in 1990 is only an example of these new stringent requirements. Special niche markets such as sports and health not only require target marketing - they also provide opportunities for developing new products such as reinvigorating waters. Pressure groups, such as environmentalists and legislators, require massive investments in R&D to devise cleaner and safer containers. And competitors are there on the look out for any miscalculation.

In spite of all these pressures and constraints, Liquid Corp. enjoys a relatively comfortable market share which gave it time to implement its experiential approach to dealing with new work technologies. It did not overtrain personnel - quite the opposite. It did not spend an enormous amount of money on training - about US$ 6,000 per trained operator, including foregone earnings. It did not introduce unnecessary computerisation into the automation lines. It did not import the latest, more sophisticated techniques of quality control - in spite of the fact that its product is submitted to more than 100 strict quality controls during the processing cycle.

Rather, Liquid Corp. chose to rely on a learn-as-you-go basis and to develop its own model of dealing with new work technologies. It decided to invest in learning about the complex socio-economic context within which it operates. It is true that it enjoyed unique conditions to learn while doing, but the important point is that it did it.

II. Computer Systems International

A. The company

The office was fairly small for the status of our host - only 2.5 by 5 metres. The only shelf in sight was fairly insignificant. Files and papers - if there were any - were kept out of sight. Over the desktop was a computer terminal, from which the director of the plant had immediate access to colleagues, clients and suppliers throughout the world. From there he could access, for example, the budget of the plant, or the status of ongoing projects. He could also reserve a meeting room, consult E-mail or six different teletext sources. Everything could be reached at the touch of a button. Even the market value of the company's shares could be checked at any moment by himself or by the 3/4 of the corporation's staff who are also shareholders of the firm. Printers of different configurations scattered over a central administrative support room could be easily accessed.

Computer Systems International (CSI) is one of the world's three largest computer manufacturers. It is the world's leader in Network Application Services, i.e. the integration of heterogenous systems formed by equipment and software with different configurations. It is also the world's leader in networking. This is where the corporation's competitive advantage lies.

The corporation currently employs 120,000 workers, and produced a total revenue of US 13 billion dollars in 1990. Markets are scattered in 70 countries, where 1,100 commercial support services and sales offices are located. The corporation also engages in a number of joint-ventures with suppliers and manufacturers, as well as software houses, distributors, and business consultant services.

A striking characteristic of CSI is that it practices what it preaches - and what it sells. Both production and office automation are intensively used by the staff. The firm constitutes in itself the world's largest industrial computer network. At its present stage, its ever-expanding internal network comprises over 35,000 nodes with hundreds of thousands of terminals attached to them. Virtually all employees have direct access to one of the 90,000 terminals - not counting the nodes and terminal at the disposal of suppliers and clients. The network is used for electronic mail, computer conferencing, joint problem solving, tele-work (people working from their homes) and, of course, for training purposes.

Technical and economic rationality - rather than marketing or public image - prevails in the choice of the computer as the central working technology at CSI. From a technical point of view, the majority of the workers are engineers or technical employees who need to use the computer to do their own jobs. From an economic point of view, several factors justify the existing level of automation, Paperless offices are not only nice and clean, they are also cost-effective. Recent evaluations demonstrated a reduction of 25 percent in the average time from concept to marketing a new product - and this has been attributed to the facilitating of technical communications provided by teleconferencing facilities.

Computers and computer communication are an integral part of the corporation's culture. Even in a country like France, where engineers and managers are not accustomed to typing their own communications and technical work, using one's own computer has become a way of life. In this culture, an employee who is unable to use a computer keyboard is considered as functionally handicapped. These rare employees with difficulty in using the computer as

a means of communication undergo a subtle process of marginalisation - a sense of exclusion from the tribe.

The intensive use of computers and computer networks also helps the corporation to develop experience with new work arrangements. Telework, for example, is being explored in joint ventures, as well as in special projects involving the firm's employees. The use of lap-top computers combined with flexible, non-fixed office arrangements is also being tested in some of the corporation's facilities. In the long run, this might become another product for the market (See ILO, 1990 for further information on Telework).

The corporation is also one of the world's largest investors in training. Over 4,000 of its staff are involved as full-time trainers. In Europe alone, the company has over 40 training sites - in addition to using other training facilities and services throughout the world. The corporation has been investing about 15 percent of its payroll in training each year. Through a specialised division, CSI also markets some training equipment, products, and services.

B. The plant and the real work

The plant analysed in this study is one of several CSI plants in Europe. It focuses on special clients and special tasks requiring state-of-the-art networking and telecommunication systems. There are no standard products - only projects which might involve the production or assembly of existing or new hardware, software and interfacing facilities. A typical project would be, for example, to interconnect the various computer systems of a major car manufacturer.

The work-flow can be summarised in four steps: the first step is an assessment of the needs of the client. Second is the development of a proposal - CSI thinks it can come up with a feasible solution. In case adequate solutions already exist, the project is handed over to other branches of the corporation which can deal with it as a routine matter. Third, the proposal is discussed with the client and, if approved, the development phase starts, and typically requires hardware and software development. The last phase consists of testing, implementation and monitoring at the client's sites. No physical production of components exists in this plant - only assembly of parts produced elsewhere by the firm or by suppliers.

The typical worker is an engineer - they comprise 75 percent of the 180 staff. Engineers are required to perform a variety of tasks, including technical sales, support, team management as well as development activities. Fifteen per cent of the employees are post-secondary level technicians, and the remaining are secretaries and other support personnel. Even though the corporation as a whole manufactures computers and produces software systems, the plant visited is clearly moved by brainpower, not the computer.

The work is usually performed in multi-disciplinary teams, under the co-ordination of a team leader. The work is also centred around clients' concrete problems - or problems brought by other branches of CSI which have been handed over to this plant. These are always new, unique, complex problems, for which in principle new solutions and systems have to be devised, designed, developed and implemented.

Competition in this business is extremely keen, as far as clients and services are concerned. This climate is reflected in the competition for highly qualified staff in the job market. Costs, reliability, quality, and delivery time are crucial factors which are routinely taken into consideration by powerful, very well informed clients. The more and better a company like CSI performs, the better its position becomes in the competition. The only guarantee to maintain a leadership position is to enlist new clients and constantly look for new and more complex problems and challenges. Otherwise, it loses its clients and its staff becomes demotivated.

At the plant visited - as in the rest of the corporation - training is also a major activity. In addition to the tele-conferencing facilities provided at each terminal, the plant has a learning centre, furnished with the latest training technology hardware, including a satellite antenna which permits engineers to undertake distance learning courses at two of the corporation's training centres. The reason so much training effort is needed is discussed in the next section.

C. A culture of training

During the sixties and seventies, literature on R&D management stressed the importance of challenging tasks to keep engineers and R&D people at the forefront of knowledge. Several studies undertaken then showed that engineers and scientists working in the forefront of their fields did not need special, additional training. Those in need of training, in general, either had special reasons, or were the people not directly involved in challenging environments, or in state-of-the-art tasks (Dalton, Thompson and Price, 1977; Pels and Andrews, 1966).

The history of CSI during the last 15 years seems to contradict these observations. In fact, the increasing investments in training by high tech enterprises seem to point to an entirely new direction. The more one is involved in cutting-edge technology, the more training is needed.

At CSI, training is an integral - and not a minor - part of management activities. It is deeply embedded in the managerial culture, and cannot be understood separately. Two characteristics of CSI's training approach will be highlighted: the personnel development plan and the concept of basic skills.

1. The Personal Development Plan

At CSI, employees sign an annual contract with their supervisors - the Job Planning & Review. In these contracts, three major items are spelled out: the goals to be reached; the means available; and the personal development plan, in which training is included.

There are only two circumstances in which training is provided: if training is needed for the accomplishment of the annual work plan or if it is part of the approved Personal Development Plan.

The first condition is usually negotiated and approved directly by the immediate supervisor, who has to ensure that the members of the team are duly equipped to perform their tasks in the best way possible. In this way, training responds primarily to short-term needs of the company. As a consequence, all training is immediately used and incorporated into work, thus maximising the returns on investment. The golden decision rule for managers is to guarantee that their staff possess the necessary expertise to perform their jobs at the desired quality level.

Even though engineers at CSI have solid technical backgrounds, additional training is still required and justified for a number of reasons, two of which stand out, and both of which are related to competitiveness. The first is the high speed of technological change. Even for a firm working in the forefront of the technology of its business, changes are frequent and very rapid.

The second reason is speed of production: to stay ahead, the firm must compete for the more challenging jobs, and to perform such jobs, there is no time to develop skills on the job, there are no skilled people available on the job market, and, as a result, it becomes necessary to train to improve internal competencies. In this way, training acts as a catalyst, as an engine for skill formation and upgrading in a very short time.

Short-term training for specific projects, however, is not enough. Individuals have long-term aspirations, and they develop their own personal development plans, which are reviewed by a managerial committee. The firm is also concerned with the professional development

of the staff. Once approved, this individual plan may also require additional training for future jobs, mobility or career transitions. This training is also paid for by the present manager - even though other managers may gain the freshly trained staff.

A permanent, structural tension exists between short and long-term priorities. Even cost-conscious supervisors, however, understand that they belong to a training culture in which both priorities are relevant. They are in the middle of a stream in which other staff members who might work for them in the future are being trained under someone else's budget. Thus, even though short-term priorities would militate against financing long-term training which is not directly related to this year's job, a pervasive culture of human resources development guarantees an adequate balance which simultaneously accommodates the interests of the immediate job, the individual's and the long-term interests of the corporation.

Yet, and in spite of the fairly sizeable overall training investment - up to 15 percent of the payroll in the last few years for the whole corporation - training budgets are scarce, and they compete with other resources allocated to the supervisors. Training investment affects both the firms's productivity, and its costs - and consequently, its effectiveness. Given increasing costs, a major trend at CSI is to increase the cost-effectiveness of training. For that purpose, the infrastructure for self-learning is being developed, including tele-courses, distance-learning, individualised instruction through computers and video-discs, and satellite-based training.

The nature, type and locus of training provided is quite varied. There are no major constraining rules. Training can be carried out internally, on the job, individually, at distance, in the plant's learning centre, in one of the firm's training centres, through internships, or in outside training centres anywhere in the world. There is no training leading to formal diplomas or degrees, and most of the training is of a short duration.

2. Basic skills

It is interesting to note that even in a high tech firm in which a typical worker has a solid engineering background one hears about basic skills training. Yet, this is certainly the case at CSI. Included among the skills considered as basic even for very high level staff are literacy in handling telecommunications and computer hardware and software. These skills are commonly required as a pre-requisite, during the recruitment process. Other prerequisites, however, may require in-company training. CSI typically requires good communications skills, particularly in the use of the telephone - and these skills are not required just for secretaries, but mostly engineers. After all, CSI is in the business of telecommunications and networking, and the ability to communicate at a distance has to be used by their technical staff at their sharpest level. Typing and English are also increasingly required at all levels. Other required basic skills are the ability to communicate through the computer and to learn to survive in a paperless office. Embedded in this skill are attitudinal factors as well as writing abilities.

D. Scenarios and challenges

It is at least intriguing that a high tech company staffed by high tech personnel needs to invest so much in training. Even though training costs need to be reduced in the long run, no dramatic reduction of these costs is in sight. The trends within CSI as a response to the need to improve the cost-effectiveness of training may suggest some reflections by those in charge of training supply.

First, the use of training technologies is becoming increasingly important, mostly for economic reasons: people's time is expensive, travel time is becoming increasingly higher, and physical displacements, in general, tend to be reduced.

At CSI this is particularly conspicuous because the basic know-how and infra-structure for

technology-based training is already there - thus making its utilisation very attractive, since it only involved relatively reduced marginal costs. Moreover, in a corporate culture in which administrative tasks, including highly technical and senior administration meetings, are held by tele-conference there is no reason why training should not follow the same route.

Second, CSI illustrates that the balance between pre- and in-service training is also shifting. Pre-service training, including that of engineers and high-level technicians, will need to consider other abilities previously neglected: writing, communicating, leading groups, speaking a foreign language, typing, as well as computer and telecommunications literacy. The high opportunity costs of in-service training, in the long run, will become prohibitive, and from a social point of view governments might want to reconsider who should be responsible for these costs, and when. Better schools teaching basic skills would certainly alleviate the costs of permanent education - so that students could then concentrate on technological updates.

Third, and for the same economic reasons, the balance of the training costs between the firm and the individuals is also starting to shift. At CSI - as in other companies - individuals are being increasingly asked to contribute their time (evenings) or even some of the costs of the training.

Binding contracts - not used by CSI - are being introduced by other companies. This is another form of shifting costs to guarantee that the individual will stay with the company at least for a limited period of time after massive training. With the increasing importance of permanent education and recurrent training it is possible that these arrangements will only be valid in particular circumstances.

Fourth, individual study, distance learning and on-the-job training will be increasingly preferred by firms over other, more expensive forms of training. Previous familiarity with these forms of learning may also form part of the basic skills to be valued by the market place in the years to come. The ability to learn, learning how to learn, might also become an imperative of a good, solid technical background.

Finally, there seems to be a need to improve the ability to deliver on-the-job training in a way that combines access to the latest available technology but which at the same time does not interfere with the smooth operations of the work. Even in high tech firms, in which the business of learning is so entangled with the business of doing, learning while doing remains a challenge.

III. Coping with the uncertainties of high-tech: The case of Avionics

Abstract. There is only one certainty about the future of high-tech firms: they will have to learn to live with uncertainty. How such firms are presently coping with future uncertainty can yield important lessons for those interested in the impact of technological change. The present study illustrates the initial stages of adaptation of the training policies and practices of Avionics - a leading European firm in the area of aviation equipment - to the uncertainties associated with technological change.

A. Introduction

Avionics is a leading European manufacturer of specialised parts for a major military and commercial airplane group in France. It also sells some of its products to other competitors. Domestic markets represent 40 per cent of sales, and are on the decline. Foreign sales have been increasing steadily and represent the most promising avenue for the future. This market is dominated by the US and the USSR, with 80 per cent of sales. Avionics competes with a few other firms for the remaining 20 per cent of the international market.

Avionics is very different from other industries which adopt new work technology to improve quality. There, quality is not just a goal, but a constraint on production. Products simply cannot fail. Ever since it was set up in the sixties, the firm has had to produce the most sensitive parts of aeroplanes to zero-defect standard. An associated and important constraint for the firm is to provide maintenance training for clients from all over the world. The firm's policy is to guarantee spare parts and after-sales technical assistance for 20 years. There is no better incentive to produce a perfect item.

Production requires mechanical, electro-mechanic, electro-chemical, and electronic processes. The firm produces a fairly large number of parts, but orders usually come in very small batches: units or dozens, in the best cases. Quality and craftsmanship are of foremost importance, and the pacing of the work is primarily regulated by these concerns. The production processes are increasingly based on CNCs, robots and other automated machinery. Even though the level of automation of single operations is fairly high, integration of production is fairly low. High tech peacefully coexists with fairly conventional production techniques.

At any time, the firm deals with over 100,000 different parts or finished products. Storage and parts handling are highly complex, and require sophisticated computer-controlled software and automation procedures. Security makes traceability and documentation of production and delivery imperative.

The shop floor is an amalgamation of small workshops, each shop with different characteristics, different staffing patterns, and different functions. The name of the game is quality. Standard definitions of productivity or efficiency are clearly subordinated to the standards of zero-defect. Frequent changes in specifications led to the production of individual, unique items, thus helping to keep the production rhythm very calm. High precision CNCs and robots performing micron-milimetric operations working side by side with traditional lathes are operated by the same craftsman. The overall climate is that of a large

and varied shop floor, with a high level of autonomy in each shop.

This paper describes and analyses two moments in the organisational development of Avionics: the first phase, in which workers were prepared to accept eventual, but yet unclear, changes, and the second, ongoing, phase, in which the individual's careers are being restructured to cope with future uncertainties. A final section discusses specific implications for training policies and practices of enterprises facing similar transformations.

B. Phase I: Anticipating change

In the early eighties, it became clear that the domestic markets would soon flatten, international competition would become harder, and technological changes would invade the workplace. What would happen, and how, was not clear. New, automated or computer controlled machines were progressively introduced and, with them, new training requirements and new work practices became necessary. The segmented, fragmented and incremental nature of these changes made it possible to slowly learn and adapt to the new production techniques.

By the mid-eighties, there was a clear awareness that incremental change in adopting new production machinery would not suffice: competition hardened, work technologies changed each day, markets became extremely volatile, quality at any price was no longer a viable proposition. The solution: the firm had to be prepared for change. What kind of changes were necessary, and what these changes would entail, however, were by no means clear.

To use an image of the trade, the strategic option adopted was to learn how to navigate under heavy turbulence, without knowing the precise destination. The only certainty was that airfields were also becoming moving targets, and that the firm should be able to land at any time, under unknown conditions.

As a consequence, it was decided that all workers had to be trained on how to cope with technological change to share in the firm's technological culture. Thus, they should be prepared to accept change - even when the meaning and implications of change were not fully known.

A first attempt to upgrade the workforce did not fly. The local technical school was invited to present a proposal for the training of the workforce. The result was a programme of advanced maths, science and applied technology, requiring high entry level standards. How could a firm face technological change without high academic levels of maths and science - asked the technical educators? Yet, only three per cent of the firm's workforce qualified - thus excluding most of the technical and non-technical workers for the proposed training on new technologies. The proposal was obviously unacceptable, and alternative solutions had to be found.

A technology literacy curriculum - which became the official policy of the enterprise - was progressively developed, based on a carefully designed psycho-pedagogical approach, and slowly implemented at all levels of the firm (Annex I). A training programme of about 170 hours was progressively implemented for groups of 12 people. Some groups met one day per week, others, two days, thus making it possible to complete the entire programme within three to six months.

The major objective of the curriculum was to prepare the entire workforce for change. The message was: we will eventually land, we don't know yet where and how, but we'd better be prepared. The firm wanted workers to become confident in their ability to learn, to trust themselves, to work in groups, and to develop positive attitudes towards changes in the workplace and in their work habits.

Three major pedagogical goals co-existed on equal footing: to know, to do, and to be. Knowledge objectives covered the basics of informatics, automation and modern manufacturing, and economics. Knowledge was in-

tegrated with doing: each subject was immediately practiced by trainees using simulators or real machines, and actual operations were demonstrated by colleagues or course participants on the shop floor. By the end of the course all participants had full knowledge of the entire operations of the plant - thus acquiring a global, concrete perspective an academic school could hardly provide. The programme also required the mastery of effective communication and group work skills.

The implicit curriculum was as important as the explicit one. Every group of 12 people was formed so that it represented a microcosm of the organisation, all the major technical and administrative functions and the gender composition of the plant. Every training session started with a clarification of the objectives of the firm and of the individuals, and ended with an evaluation of individual and group goal attainment. All individuals were expected to succeed - and success was equally the responsibility of the student, the group and the trainer. Self-confidence, awareness of interdependence and confidence in group work were the results expected to be derived from the course design. A common language and a basic knowledge of all the activities of the firm were thus progressively developed.

This training programme became part of the company's personnel and training policies. All groups under training were allowed to request the presence of the director of the plant to discuss the concepts presented in the course or to inquire about changes occurring in the workplace. Several groups took advantage of this opportunity and the director never failed to participate in these debates.

A number of evaluation exercises were performed, during and after the training programme. The objective was to ensure that all that was taught was actually used by the trainees, either during the course, or during the next few months.

The most visible result on the first groups of trainees was soon perceived by supervisors: graduates came out different from what they were before training. They were now pressing for changes; they wanted to participate; they asked more questions; they gave their opinions; they became more interested to learn; they asked for more autonomy. Methods engineers, for example, reported on how much easier it was to perform work analysis and to introduce automation in workshops where participants had gone through the basic technology literacy training. Two other consequences were immediately felt. First, supervisors and other higher level technicians voluntarily applied for the course: they knew there were things to be learned. Second, over 50 per cent of those taking other higher level technical courses were graduates from the basic technology literacy course - even when the course was not compulsory for technicians and other higher-level workers. Among other things, this suggests that workers have acquired not only the conditions, but also the motivation, to undertake further, more specialised training. And through their new inquisitive behaviour and sense of self-confidence, they were putting more pressure on their supervisors.

Training, however, did not lead to immediate changes in the workplace. Training obviously facilitated the introduction of automation. But supervisors were becoming impatient. When would changes come? What would change? Questions were raised at all levels of the organisation about the worth of this kind of training - which was challenging existing work practices. Suddenly, but not unexpectedly, change happened.

1. A stranger named Boeing

It was not entirely accidental, but receiving commissions from Boeing led to major changes in the organisation of production. Large batches of eight to ten parts were now replaced by orders of 120 or more. Product cycles of 18 months had to be cut down to six months. Tighter deadlines, tighter cost-control, more detailed documentation became imperative. Rhythm of production also changed. New dimensions of quality were emphasised. Cost at any price was being replaced by a new concept: what quality for what mission, at what price.

New materials were introduced. Variety increased even further. Manuals and specifications were handed down in English - a foreign language. And everything had to be coped with at once.

Avionics successfully passed the test - at least during the first three years of this new contract. Adaptation came very swiftly. Personnel started moving from one post to the other, without many problems of adaptation. In the first year of this contract, over 90 workers, representing over 15 per cent of the total workforce, changed jobs and all of these performed adequately in the new functions. Training for flexibility seemed to have paid off, with positive dividends. Even though the organisation of the workplace did not yet undergo dramatic change, work practices and work relations were visibly changing.

But this was not the end of line. The future was (or is) yet to come, and another anticipatory phase was already emerging.

C. Phase II: From training to career planning

Technology does not lie in the machinery: it lies in peoples heads. Otherwise, how would a giant like Boeing, in a country flooded with high tech industries, bother to identify suppliers abroad? Knowledge and skills, however, are bound to become obsolete quickly in the world of high tech. Attitudes are harder to change. Preaching and teaching can help to change attitudes, as demonstrated in phase I, but this is certainly not enough. Self-sustaining change had to be guaranteed by more profound changes in the ways workers conceived their roles and careers- and the need to learn and to adapt to new circumstances.

The next stage towards the future consisted of working on individuals' career plans. For many years Avionics operated with a blank check from employees: there was no definition of jobs and tasks. Workers are workers - within constraints, of course. Workers knew what they knew, and had to do what they were capable of doing. They were allocated to jobs as a result of matching needs with competencies - and work arrangements had been traditionally flexible. Multi-skilling and multi-tasks were traditional characteristics of small workshops, and in the case of Avionics, they contributed to enhancing its competitive advantage to face technological change.

Once the technology literacy course was firmly in place, and the whole range of high tech courses was made available to those in need - the second phase started to unfold itself. The centre of action was the annual performance evaluation section, where individual training needs are discussed with supervisors. Individuals are asked to think ahead and plan their careers - and to include personal suggestions for training and mobility. Supervisors are asked to comment and to present the skills needs of their individual shops. The personnel department attempts to find optimal solutions, adding to these considerations the long-term policies and interests of the firm as a whole.

Training and job-rotation plans are then developed, to maximise shop, firm and individual preferences. There is an explicit attempt to maintain previous professional identifications and to incorporate previous knowledge and experience into new areas. For example, a manual lathe operator transferred to a CNC is encouraged to return to his manual lathe from time to time, at prescribed opportunities. A mechanic turned into an apprentice mechatronics technician keeps split appointments or split times - to reinforce his previously acquired competencies.

Mechatronics is a denomination initially employed in Japan to acknowledge the multi-skilling of production and maintenance specialists able to simultaneously deal with mechanic, electric and electronic aspects of new work technologies. For a detailed discussion see ILO/APSDEP, 1988.

A cabling specialist combines his expertise with newly acquired skills, lathe adjustment, under a flexible work arrangement negotiated between two sections. According to the personnel department, such changes would not have been possible without the previous unfreezing phase. Individuals now anticipate, rather then wait, for the changes.

Studies are now underway to reconcile remuneration policies with upskilling and multi-skilling. A few policy changes are underway, but not in any systematised form. The idea is to put in place a wage premium on versatility and to pay for what the individual is able to do - not for the tasks he is presently performing. Past experience has shown that more versatile individuals received more promotions. This acts as vicarious reinforcement for other workers. Unions did not present major obstacles - in part because a clear majority of workers approved of the system. Moreover, there was no case of de-skilling, since the variety of jobs and workstations made it possible for individuals to continue in their previous jobs, or move to similar ones.

D. Discussion

As we learn more about how organisations cope with technological change, a few common trends seem to emerge from the variety of situations, problems and solutions. In the present section we discuss four issues which might be of general interest: coping with uncertainty; the nature of basic skills; under and over-investment in training; and the implications for organisational learning. The purpose of the discussion is not to evaluate what happened at Avionics, but to learn from its experience.

1. Coping with uncertainty

Training is certainly a critical component in a firm's strategy to deal with the uncertainties associated with modern manufacturing and modern work technologies. What are right and wrong training policies, however, can only be judged retroactively, with the benefit of hindsight. And even then, there is no control group - and there are various possible interpretations for whatever happened or failed to happen as a result of training.

In this case, flexibility and positive attitudes towards technological change introduced through training clearly seemed to have paid off. There are empirical indicators concerning the ability of the firm to adjust - as reflected, for example, in the speed at which new production cycles are introduced or in the volume of employees taking over new and generally more complex jobs.

2. The nature of basic technological skills

The actual contents of the basic technology skills programme is probably at least as relevant as the way in which it is delivered: how management is involved; the voluntary criteria of participation; group responsibility for an individual's results; group dynamics - in other words, the hidden curricula.

For a firm such as Avionics, basic technological training had one clear goal: to spread its technological culture. For that, it had to become universal within the firm. This is parallel to the phenomenon of the universalisation of literacy followed by basic education and then by secondary education observed in Europe and other industrialised countries during the last two centuries.

The actual nature and content of these basic skills, however, vary between companies, and over time within the same company. For Avionics, the important message was to prepare people for change. Using technological contents and examples from the workplace was merely a training strategy to increase the attractiveness of the package. The firm, in fact, experimented earlier with other techniques, such as the Raman method, and considered using P.I.E. (Programme of Instrument Enrichment), both of which use abstract approaches to unfreeze learning habits and unleash learning potential (see Raman and PIE). The conclusion was that even though these techniques

would probably achieve similar results, using the technological contents and situations actually employed by the firm would be more motivating. This decision also reflects the fact that the really critical skills are not specific knowledge of information, but attitudes towards oneself and towards change. At the same time, it reinforces the importance of using context-relevant topics when dealing with adults.

Additional concrete, specific basic skills needs, however, might emerge over time. Working with an English-speaking client required a number of workers to quickly acquire foreign language skills. It is interesting to note that three levels of such skills were quickly provided by the firm: ability to read manuals and instructions; ability to prepare specifications and contracts; ability to negotiate. These three different training options were offered, and more than 15 per cent of the workers were immediately engaged in these courses.

As one looks into what is happening with training and work relationships in other high tech firms, industries and countries, a few similarities start to emerge. At earlier stages, a positive attitude to change and to learning are considered a first and necessary pre-requisite - before any contents can be taught, or any change in work technology can be succesfully introduced. Pedagogics needs to be taken seriously, and competently treated: in a first stage, it is more important for employees to learn how to learn than to actually absorb specific contents, or to master specific skills. Hence follows the need to find suitable methods and instructors, and to involve participants as important actors of the training process.

Here we are talking about generic, basic skills - which are presumably taught by schools. But apparently schools did not - or still do not- do a good job. Moreover, firms seem to enjoy comparative advantages to teach such skills which today have become job-relevant. First, firms can provide concrete motivation for the expected changes. Second, they can provide a meaningful context for learning. Third, they can provide a nurturing environment. Whether or not schools can do it is a matter to be further investigated. In the case of Avionics, the neighbouring technical school did not respond adequately. Yet, it is curious to note that, after having developed its own curricula, Avionics trained the instructors from the same neighboring technical school it contacted before to deliver its technology literacy programme.

3. Investing in training: under- or over- investment?

High tech increases the need for skills, and the need for training. True or false?

Even though it is tempting to say that it is true, one must be careful about estimating new training needs and the necessary costs to meet such needs. Comparisons between firms and industries are even riskier. One must also be aware of the risks and costs of over-training

In the past - and until the very recent past - relatively little training was done by industries, or within the industry - training was concentrated on managers and a few highly qualified workers. Second, there was - and still is - a lack of adequate professional schools to train technicians to deal with the complexity of new work technologies. Schools and firms are still learning to deal with these new challenges. Moreover, the transition from old to new modes of work is made with existing workers - hence the need for the Herculean training efforts observed in many places. But more important than these two reasons, however, was the lack of use of people's competencies under former work structures. People not only did not need to think - but in many cases they were negatively rewarded when they did. Unfreezing old habits and instilling new ones takes a great deal of training - and much more.

Training requirements, however, do not derive directly from technologies. There seems to be no such thing as training imperatives imposed by technologies. A new work technology can bring in upskilling or de-skilling requirements for operators, depending on the way it is conceived and implemented. In general, however,

new work technologies tend to require higher maintenance skills, regardless of who performs them. Redefinition of work does not also follow automatically from introducing new hardware: working with CNCs can be an experience of job enrichment or of job impoverishment. Avionics' experience in this matter is very illuminating. Whenever new tech jobs were associated with greater complexity such as programming or maintenance, more skilled craftsman opted to join in the new facility. Whenever it led to de-skilling, they opted to stay working with their conventional production tools.

Overall, however, work flexibility seems to be perceived as an asset for firms, and possibly for individuals. For the latter it might represent job security, a more interesting job, more training, better career opportunities, or better salaries. None of these, however, follow automatically from technology - and in most instances, they are in clear contradiction to it.

Examining training costs. High tech firms tend to make significant investments in training, and figures of five to eight per cent of the payroll are usually associated with highly performing firms. Avionics has been steadily spending more than three per cent of its payroll in training in recent years and is unlikely to increase such expenditures. Is this a good or a bad sign?

First, the most important types of training and new learning take place on the job, and usually after workers have gone through the unfreezing process. It is virtually impossible to estimate the costs of this learning and the efforts of the firm to make them occur. In many cases and, in fact, in the most effective cases, it becomes increasingly difficult to separate work from training and learning. This could lead to the impression that the better firms are the ones with lower training costs.

Second, there is a physical limit to formal training activities. According to Avionics' officials, they have reached such a limit, which represents about 18,000 - 20,000 working hours per year. This is equivalent to 2400-2700 man/days per year, which is roughly equivalent to 10-12 workers being trained full time every day, or 1.5 per cent of manpower being permanently involved in formal training activities. Increasing that level would become dysfunctional, compromise production and complicate co-ordination.

Third, costs of training are not so simple to estimate and to compare. In some countries training costs include the salaries of trainees. The direct costs of training provided by firms themselves typically costs 1/3 of the cost of training provided by the market. Many training costs are embedded into supplier's contracts and are usually omitted from calculations. The costs of training departments may vary, according to different functions, equipment used, and relative efficiency. The phase of technology adoption by the firm also reflects on the relative intensity of formal training required. Finally, raising the entry level requirements contributes to lower training costs. In recent years, Avionics has been recruiting operators with eight years of basic education and a minimum of three years of vocational or technical training, thus transferring some of the training costs back to the educational system.

Therefore, costs must be analysed with caution. What seems obvious, however, is that firms using high tech production technologies would like to do more training, if they could - even when then are aware of the fact that in many cases the new skills learned will not be immediately used. But the more important impact of training is reflected on the firm's competitive advantage, its improved efficiency, and its ability to learn from its own employees. This is the topic of our last section.

4. Organisational learning

The literature seems to suggest that the efficient use of new work technologies is associated with the permanent capacity of organisations to learn (Hoffman & Klapinsky, 1988). Such a capacity is related to new work arrangements, job redesign, training, and other attitudinal changes such as those reflected in

basic skills training programmes as the one illustrated above.

Several indicators might be developed for measuring the extent to which an organisation can learn. In the long run they are represented by sales, profits, survival, leadership, etc. Proxies, indicators, and other direct measures could be, for example: additional training taken by workers; on the job learning; improved morale and satisfaction; some measure of worker flexibility to occupy different jobs; degree of participation in quality or efficiency campaigns; rate of utilisation by the firm of the suggestions presented by employees.

A few unobtrusive indicators from Avionics seem to suggest that it is becoming an active learning organisation. The most obvious evidence was the ability to respond to the new challenge brought in by the contract with Boeing. The idea of disseminating a basic technological culture and a common vocabulary is another possible indicator. The promotion of flexible careers is another. The changes in the daily lives of workshops, harder to analyse, would possibly provide additional evidence on the firm's ability to learn.

What might be useful to analyse, however, is the learning process of dealing with technology, training and organisational change. This process is far from linear. Hoffman (1989) suggested that organisational changes are more likely to improve productivity - and organisational learning ability - than new technological tools. Piore and Sabel (1984) had previously demonstrated that the work pattern of broader, non-tayloristic workshops can be more conducive to multi-skilling and sharing of knowledge. This is what allows new technology to more readily and efficiently fit in, even without major organisational changes. The leading international role acquired by small ceramics and garment industries in Italy is attributed to this organisational feature (Porter, 1990).

Some inconsistencies, anachronisms and contradictions remain, which illustrate the socio-psychological difficulties of implementing change, particularly in large organisations. Remuneration policies, for example, do not always reward polyvalence or multi-skilling. Another contradiction which is acutely felt by Avionics is the lack of harmony between its training policies of promoting group work and the incentive policies concerning suggestions to improve the efficiency of the operations: workers can receive rewards for individual suggestions, but there is no structure to remunerate group initiatives. Only one attempt was made so far, and its lessons are far from encouraging. The problem is not an easy one to solve - and has deep cultural and labour-relation implications. But it is certainly one example of the difficulties of implementing needed changes in the workplace which could possibly make organisations and individuals learn even faster.

Avionics, for one, is convinced that its major assets are not the machines, or its current know-how, which materialised in present work processes and industrial secrets, but the know-how mastered by its staff. Implementing the necessary organisational changes to sustain the development of this know-how over time is a challenge that still remains to be faced. And this know-how is even more difficult to master than it is to learn how to operate sophisticated equipment.

The readiness is all. The present case study illustrates how new work technology brings with it new organisational formats and pervasive, new training requirements. Every worker - not only technicians - needs to be prepared for change, and to be at least minimally literate in the language of high tech. However, there is nothing deterministic about new work technologies: they can lead to upskilling or de-skilling of individual workers; they can enrich or impoverish specific work places; they can create unemployment for those replaced by the machines but more often they generate new employment through expansion, or increased business for other firms. Two constants seem to emerge from this and other studies: first, technological change is primarily a human affair. The socio-psychological and cultural aspects are at least as impor-

tant, if not more so, than the technical ones. Second, amid so much uncertainty, change is certain. Firms and individuals must be prepared for it. High tech industries seem to have accepted the mandate from the 21th Century Technology Ghost, and, like Hamlet, they are now ready to act.

IV. Control Panel Corporation

A. The factory

Located in a high-tech region, CPC (Control Panel Corporation) produces mechanical, electric, and electronic components for the automobile industry. Its major products are commuters and interconnecting boxes for cabling and disjointers.

Total sales in 1990 reached about 16 million dollars. As a specialised supplier, its few, special clients include automobile manufacturers in France, Italy and the Scandinavian countries. The firm has been undergoing steady growth during the last ten years. As a specialised supplier of a single industrial sector, CPC is obviously affected by any changes in the behaviour of the automobile sector.

Products extend over a range of 150 families of products, 4,000 to 5,000 individual items, of which from 500 to 600 types are produced on any given day either by the firm or by its suppliers.

The production strategy is very clear-cut: the firm produces the more complex and challenging items in its own plant, as well as any parts requiring automated equipment for their manufacturing. Other items, including most of the low-batch orders, are produced by a large number of suppliers. The firm has contractual agreements to produce parts for vehicles up to ten years after they are taken out of the production line. In some cases orders of as few as 20 low-cost items have to be filled.

Besides manufacturing some items, CPC designs their new products, designs and produces most of their machine tools and production systems, and undertakes significant R&D activities. A major factor of competitive advantage in its markets lies in the process and production technologies adopted, rather than in product innovation. Thus, mechanical competence is a major asset of the firm, and has to be acquired through intensive local R&D efforts and incorporated into the production process. The manufacturing basis is essentially mechanic - and CPC shares in the mechanical culture as supplier of the automobile industry.

B. The process of automating

The process of automation at CPC started slowly in the early 80s, and took a decisive turn in the mid-80s. Automation was essentially driven by three external and inter-related factors: productivity, costs and quality. Large-scale orders justified the use of automated production techniques; costs had to be kept as low as possible if the firm was to survive competition. Quality had to improve to respond to the new requirements of an increasingly demanding automobile industry. By the mid-80s, automated technologies had evolved to a point at which it became reasonably cost-effective for batches of over 100,000 parts per month.

New work technologies were simultaneously and progressively introduced at various phases of the R&D, design and production process: computer-aided design, computer design of machine-tools, automation of specific production processes, automation of quality and other controls as well as office automation.

The variety of parts produced by CPC made it very attractive to invest in CAD techniques as well as in the design of special machine tools, in an industry where the competitive advantage derives, to a great extent, from the process technologies adopted.

Production automation per se was progressively introduced and decisions were mostly based on cost-effectiveness criteria. Automation was greatly facilitated by the nature of the production process, which consists mostly of rigid manufacturing islands with virtually no need to integrate production units, which, in most cases, operate in fairly long production runs. CPC consistently adopted a business strategy which allowed it to concentrate on the manufacturing of the more complex, delicate products and the automated machine tools, leaving to traditional production lines and subcontractors most of the routine, simpler work usually involving low batches.

According to its management, CPC has been able to keep abreast of the technology in its field by adopting a selective production strategy, as it concerns both products and the machine tools required for production. This has allowed CPC to maintain its competitive position in the market. Even though it is not a leading actor as far as product innovation is concerned, it has been able to incorporate the latest product and process technologies within a year of its first appearance in the Japanese market.

C. The central challenges of production

Production is organised around individual products, each machine or production line being responsible for a single product or a family of products with slight variations. Very little direct interaction or interdependence exists between different product lines. In spite of operating with just-in-time techniques, buffering stocks guarantee the independent functioning of the various lines, or even of specialised machines within a given line, so that interruptions in one machine do not interfere with the output of another.

Traditional production lines co-exist with fixed-automation lines on the same shop-floor. The decision to automate any single line is basically guided by cost-effectiveness concerns. Automation is typically adopted for production batches of over 100,000 to 150,000 parts per month.

Production is constrained by two critical and familiar challenges: efficiency and quality. Efficiency is dependent upon carefully designed machine-tools and production processes, and is ensured by the smooth operations of the machines - automated or not. The production process requires active maintenance crews with highly developed mechanical skills necessary for recurrent tooling and retooling of the machines. But the introduction of automation created the need for additional skills in new areas, particularly in electronics. Changes in the technology and rhythm of production also required new forms of interaction and hence the need for better communication skills among the workers, technicians and their supervisors.

The other critical issue is quality. With increasingly higher quality standards imposed by the customers, quality became a fixed constraint on production. For most products, the current quality standard is 1,000 per million parts. For some others, it is zero defect. Operating under such constraints requires tighter control of suppliers of raw materials and parts, constant improvement of production processes, the transfer of routine quality control activities to the line, and the permanent upgrading of quality control techniques, tools, analysis and interventions.

As stated before, efficiency was dealt with mostly through automation and a division of labour between the plant and the constellation of suppliers involved in the manufacturing of less complex, low-batch items. In the next section we examine in more depth the impact of higher quality standards on training.

D. Quality: From one per cent to 1,000 per million

It was probably not by coincidence that the only item lying on the factory director's desk during

our visit was a book on quality. It was probably also not by chance that the word quality came out of his mouth approximately once in every three minutes. Why so much concern for quality?

The response is simple: automobile markets are becoming increasingly demanding. Even a relatively trivial button in a control panel must not fail - the costs of repair, replacement and damage to the image of the manufacturer of the car are just too high.

In the space of ten years CPC has seen quality requirements soar from 1 per hundred to 1,000 per million, which is equivalent to 1 part per 100,000. And yet, this is a theoretical tolerance: this is only the minimum acceptable margin of error for several products which would allow CPC not to be disqualified as a supplier. The actual products delivered have to be 100% error-free.

The case of a commuting device which activates the ABS (anti-breaking system) illustrates the impact of high quality standards. This device needs to be perfectly isolated and impermeable. Isolation defects cannot be tolerated. Yet, errors can arise from a variety of sources: the quality of the plastic used, the geometry of the plastic boxes, the position of the contact plates, the sensitivity/conductivity of the materials. That in turn depends on the quality of the metal used, the precision of the position of the plates within the box, and the quality of the welding.

Producing a zero-defect device such as this while controlling a large number of variables required important changes in the whole production process. The design of a new part, and the machine tools to manufacture it with total precision, not only requires experienced experts, but the field experience of the people involved in the production process as well. It involves very strict quality control over the suppliers of the materials and the constant updating, measuring, testing and quality control mechanisms. As a result, all the people involved in this process, including the operators, need to understand what is involved in a zero-defect part. Operators need to pay attention to minimal deviations from the norm, and to be able to inform, communicate and act promptly and with precision. The participation of the entire production and support crews is essential to meet the specified standards of quality.

E. Upskilling the entire workforce

At CPC, technical complexity relies much more on product and machine-tool design than on actual operation. Operations are relatively simple, discrete and routine. Even though rigid automation creates additional requirements for the production process, these in themselves would hardly require the massive upgrading of the labour force observed at the firm. But automation coupled with infinitely small margins of tolerance and very small room for inefficiency explains the pervasive upskilling of the labour force being undertaken by CPC, which is analysed in the last section.

Between 1985 and 1991 the labour force at CPC increased from 600 to 680 workers. Meanwhile production doubled. In 1985, there were about 200 indirect workers and 400 directly involved in production. In 1991, there were about 300 direct, and 380 indirect workers. The present trend has been to increase the number of indirect, highly skilled workers. In 1985 there were 30 employees formally classified as technicians, holding CPA, BTN, BTS or equivalent certificates. These are the French names for technical qualifications at the post-primary, technical secondary or post-secondary levels respectively.

In 1991 there were 100 such technicians. Between 1989 and 1991, 40 people were fired, and 30 hired. All the new entrants had technical qualifications. All 40 leaving the firm had no technical qualification, and for one reason or another were considered by the firms as unfit to take additional training. Overall, the total value of CPC's pay-roll increased significantly during that period, even though the relative weight of personnel costs diminished, given the increases in productivity.

These figures are a very eloquent illustration of what is commonly called upskilling. At CPC, virtually all workers were affected by technological change and the quality revolution that it entailed.

Let us consider the case of the operators who continued to work in conventional production lines. Since overall quality standards were raised - independent of the production process utilised by the manufacturer - these same operators are now required to understand and deal with quality issues: they have to read specifications in order to check the conformity of the parts with the standards; they need to perform routine quality inspection - since quality inspectors no longer exist. And, if they want to be engaged in the new, automated production lines, they have to undergo training. CPC is having difficulty in keeping traditional employees with low levels of literacy, because of their inability to read basic instructions and to fill quality control forms. High tech does not seem to mix well with low education.

Operators of the automated machines had their jobs significantly enriched. Manual dexterity is no longer required - but new, more abstract skills are mandatory. Such skills may include principles and techniques of quality control, understanding the logic of the operations, checking for possible types and causes of defects, even for minute departures from standards. It is also imperative that operators communicate effectively with the first-level maintenance crew about machine stoppages, and that they contribute to quality-control circles and quality-improvement projects. Training for operators varies with the nature of the operation, and usually takes anywhere from 40 to 150 and more hours.

The first-level maintenance crew (toolers, instrumentists) jobs were also altered, to include preventive maintenance, quality control, and much more involvement in corrective maintenance. Additional training - which may last for several weeks - includes basic electronics and automation, as well as problem solving techniques.

The group most affected by the new work technologies are the middle and higher level technicians (BT, BTN, BTS). Given the nature of the work performed at CPC, a solid mechanical background is required. Training is highly individualised, depending on the work requirements: quality, automation, and electronics and computer-related subjects are the most common topics. Most of this training is provided by outside training suppliers. An important part of training consists of talking to experienced operators on the shop floor, as well as with their customers. Ability to communicate and to encourage communication from others, closer to the production line, thus becomes a critical element of the training process.

Finally, supervisors (agents de maîtrise) are also undergoing dramatic changes in the nature of their work. They are being asked to develop people- and systems-oriented skills, and to act as linking-pins between the increasingly sophisticated operators and the providers of technical support and innovations.

As a result, a workforce with a new profile is slowly emerging. For those workers coming from a previous generation, and who demonstrate motivation and an ability to learn, training represents a job guarantee and a gateway to mobility. In the case of CPC, an equivalent level of at least eight years of basic education - i. e, the ability to read manuals and instructions, write and perform basic computations is commonly perceived as a minimum prerequisite. No longer does it suffice to be nice, clean, and to display the virtues of patience and accuracy - typical of the docile and poorly-schooled feminine workforce attracted to these jobs in the past.

As far as new recruits are concerned, the policy is to hire people with a technical background (CAP and above) and to provide additional training depending on their interest and on the needs of the firm. Even though the managers of the firm recognise that there is no longer a limit to training needs, a ceiling must be established, based on considerations of costs, efficiency and a tolerable level of disturbance of

regular operations. Training costs have doubled in the past five years, now representing two per cent of the pay-roll.

Training per se, however, is not enough. Changes in the work process also entail changes in the incentive systems and remuneration policies. In the past, CPC used to provide incentives based on a piece-rate, but that practice was discontinued with the advent of automated machines. A new incentive system is now being implemented, to take account of other critical variables, such as productivity, multi-skilling (ability to perform different tasks), quality of output, and group participation. Such a scheme has the potential of increasing motivation for further training, job mobility and productivity, while at the same time rewarding quality improvements through individual and group performance.

The central lesson to be learned from CPC is simple and straightforward: technology brings in new dimensions and new demands for product quality. Zero-defect, near perfect product quality require dramatic improvements and qualitative changes in the nature and organisation of the production process.

These factors bring in both new threats and new opportunities for the labour force. In general, it has been possible to re-train the existing workforce and to make the jobs broader, more interesting and more challenging. So far the message has been very clear: those with lower levels of education and training face major risks - including that of unemployment. Those with better levels of education and training are likely to benefit.

V. Intelligent Pots, Inc.

A. The business of Intelligent Pots, Inc.

Intelligent Pots is the world's leader in coated kitchenware (pots and pans). It controls 80 per cent of French markets, enjoys a comfortable position in the major European countries and maintains first place in North America, with 20 per cent of the market share.

Sales reached 1.1 billion FF in 1990 (US 200 million), 60 per cent of which was represented by exports. Virtually all the production facilities and the staff of 1,700 people are concentrated in one single place.

The firm concentrates on four major activities, all of which cater to a single market: household appliances. First, there are the traditional products, based on the firm's patented technology for revesting pots and pans. There is a family of more than 30 products and up to 4,000 different product specifications. Second, there are the electro-domestic appliances. Another two new lines of products have evolved since the mid-eighties: digital scales, which also use technologies developed in-house, and domestic telephones, which were developed under subcontracting arrangements.

Intelligent Pots prospered under the protection of a patent, registered in 1956 for recovering aluminium plates and which allowed the company to launch an unchallenged new product in the world's markets and to ensure its leadership until today. Manufacturing operations started in 1961, and by the late seventies growing competition forced the firm to look for more efficient and flexible production technologies. Competition also forced the firm to constantly seek to improve the presentation and the aesthetics of its products. Automation has since been instrumental in maintaining and expanding the firm's competitive advantage.

As a result of these developments, Intelligent Pots is now able to combine its knowledge of automation technologies with its home-appliances market expertise to enter the expanding area of domotics. New domotic products now being developed, to be marketed in early 1992.

Domotics the application of information technologies to the home. The cliché is the image of the robot performing household chores such as sweeping floors and washing dishes. Domotics products may range from safety items to programmable ovens. Artificial intelligence techniques may help devise balanced diets and make shopping lists. In the future, it might include intelligent pots and pans.

B. The automation process

The production of pots, pans and related kitchen appliances involves a relatively reduced number of operations, with slight variations. It typically involves pressing the revested metal sheet to give it the desired shape, and then finishing it up, which might involve toiling, painting, enameling, fixing holders, inspection and packing. Besides, there are different painting or enameling processes, depending on the product, as well as different types of finishing.

Most of the production is performed by small production islands composed of three to five machines. The competitive edge of the firm lies in the treatment of metallic surfaces, which gives its products unique characteristics. There are different levels of automation and integration, ranging from manually-operated

machines, mixed manual and mechanised or automated operations, including robots, to fully or almost fully integrated production islands, involving, for example, pressing, moulding, scraping, enameling operations.

The automation of production lines started in 1980 and has been progressively evolving ever since. New and old equipment, new and old staff co-exist on the same production floor. There is also a combination of fixed and flexible automation. The two major production constraints - productivity and flexibility - conflict with each other and create the pressures within which supervisors, operators, retooling and maintenance crews have to operate.

Production batches can be as low as a few hundred units - thus requiring three to four retoolings of the machines each day. With automation, training and better organisation practices, retooling time has been decreasing from 20-30 minutes to under ten minutes on average. After the operation of a new product starts, the critical challenge for production is to avoid down time and to keep the machines operating. Even though productivity and quality are mostly regulated by the technology embedded in the products, work processes, or in the machines themselves, some adjustments and fine tuning on the programming of the machine are constantly required to keep the production process within the desired standards.

C. Automation at Intelligent Pots

Three major characteristics stand out in an analysis of the automation process at Intelligent Pots: the relatively slow, progressive, and steady rhythm of implementation; the management of uncertainty; and the changes in work organisation. In the following paragraphs, we turn our attention to each one of these three features.

1.Slow, progressive and steady rhythm of implementation

Automation was and still is being implemented slowly and progressively. Since the early stages, the corporation decided to master all the aspects related to the automation of its operations, instead of relying on outside consultants. Before ordering the first robot, methods personnel were trained on systems and automated production engineering methods, up to a point which made it possible for them to specify the systems and the robots to be bought. Once bought, the first robot was adapted, programmed and installed by the firm's own personnel, without technical assistance from the outside. The same process has been repeated ever since. There is nothing spectacular in that process: every new step is an anti-climax. As a result, staff of the firm are under total control of the entire production process. To ensure that production technology is fully mastered and to increase the efficiency of automation, staff from the systems and methods units are encouraged to take on production responsibilities, and vice-versa, thus eliminating the gap between thinkers and doers. The progressive, sequential, and constant rhythm of innovation allows the firm to provide training mostly on-the-job for the operators and maintenance crews in charge of the new equipment.

2. The management of uncertainty

As far as uncertainty is concerned, the firm maintains a careful, but clear, approach to product innovation. Its business strategy consists of constantly expanding and improving products for the same home and kitchen appliance market, while progressively incorporating technology and automation into its products. Familiarity with both ends, markets and automation, leads the firm very naturally to the realm of domotics - which consists of the marriage of automation with the functioning of the home. True, the firm might never actually produce intelligent pots, but its present market strategies allow it to cover most of the uncertainties related to changes in home appliance markets.

A striking characteristic of the firm's approach to technology is its synergistic way of dealing with change. On the one hand, the firm soon learned to deal with product change - by zeroing in on the home appliances market and constantly upgrading and increasing its product range. All its product lines cater for the same market. On the other hand, the approach the firm adopted to automate production processes, machines and tools led to a progressive and steady mastering of automation technologies.

3. Changes in work organisation

Much has been written about the importance of organisational change in relation to new work technologies. Some authors (Hoffman, 1989) even argue that organisational change not only must precede - but in fact it is more effective than introducing automation equipment per se. Kanban is a case in point. This is a method of stock control which made it possible to introduce "Just in Time Techniques" into Japanese firms. No physical equipment of computer-based control systems is required for its successful implementation. Yet the results in terms of diminishing the levels and costs of stocks and storage can be astonishing. The evidence to support Hoffman's arguments is very strong and rather compelling (Elam, 1989).

Intelligent Pots seems to stress a different type of change in the workplace, although it is not in contradiction with Kaplinski's observations. Organisational structures have not changed with automation - in fact they remain basically the same. Hierarchical levels also have not been reduced - but it is important to observe that the hierarchical levels on the production floor were already very flat even before automation: a production chief, a supervisor with a staff of maintenance, operators and a few non-qualified workers. New jobs have not been created - except for the figure of the line conductor, an operator who is now entirely responsible for an integrated production line.

Yet, below this apparent immutability, two sets of dramatic changes affect the way in which work is organised, and they relate to the functions and the attitudes of the workers.

Job descriptions and the jobs themselves have changed for virtually everyone involved with the new automated machines. Even though the extent of the changes varies with almost each production line, the trends point in the same direction: workers perform more tasks, operators are involved in quality control, maintenance chores and increasing the need for diagnosing and communication (of faults) throughout the hierarchical lines. For maintenance crews automation requires broader qualifications and competencies, instead of the previously highly specialised and compartmentalised functions of mechanics and electricians, for example. For the supervisors, automation introduced further complexity and required new attitudes concerning communication with operators and line conductors and new competencies to manage technical functions which are, very often, beyond their knowledge.

These new tasks entailed a change in the attitudes and behaviour of the staff. Marked changes have occurred since the introduction of automation. According to our informants, people seem to have understood the importance of productivity and quality; they seem to have understood that adapting and changing is a matter of survival - not only for the company but also for themselves. They have seen their colleagues with more and broader skills go up the organisation ladder. They seem to have understood that production is a joint effort - and that collaborating, contributing and finding the right problems and the right solutions is part of their jobs. Operators and line conductors express themselves more freely and more openly than in the past. And maintenance crews, supervisors and methods specialists ask more questions and are more ready to listen.

Once again, nothing spectacular occurred at Intelligent Pots. No major reorganisation was undertaken. No jobs were lost, no blood was shed. No changes occurred in organisational charts. No hard fights with the local union were fought. Not even major changes in salary structures or monetary incentive systems were in-

troduced. Organisational change occurs, yes, but mostly in the minds and hearts of the people.

For lack of other explanation, and in the absence of more explicit incentive systems, two variables seem to have played a role in facilitating such changes, which can be rather dramatic in other organisations. A first explanation is risk avoidance by the individuals concerned: workers will avoid risking their job, or lagging behind as their more skilled colleagues are promoted. This, however, might not be enough to accept changes in the workplace - as is demonstrated in the case of other firms which failed to adjust because of lack of internal support. The second explanatory variable is associated with the role of education and training, to which we now turn our analysis.

D. Developing human resources

At Intelligent Pots, training preceded automation: the first robot was commissioned by people who were intensively trained before they were able, themselves, to draw up the specifications, to monitor the production process, to adapt the robot to their needs, to programme it, and to implement the whole process, including the training of operators and maintenance crews.

Explicit and implicit training strategies have been intensively deployed since the early eighties. The major characteristics of these efforts are as follows:

- Training involved the whole staff, but major efforts were geared to lower-level staff. As a consequence, all employees are required to follow the common training core, a four-day intensive workshop including the basics of economics, communications, quality, informatics, and safety.

- Most of the workers, starting with the operators, are supposed to follow a two-stage training programme. The first part - a five-day in-plant workshop - consists of an introduction to new work technology and automated work tools. The second part consists of a dual-system type of arrangement which extends over an 11-week period, during which operators take specialised courses on one area of their actual work, which might be electricity, pneumatics, hydraulics or robotics.

- Specialised technical training courses or on-the-job training are provided for mechanics, maintenance crews, and other higher-level technicians, according to specific needs. Managerial training emphasises communications, motivation and joint work.

- General education and technical courses are encouraged, and sometimes they become mandatory. These might include training on the use of specific software packages, training in effective group work, communication techniques, as well as labour legislation and security. The firm also encourages and finances evening courses in languages and informatics for all those interested. Over 100 staff members have completed informatics courses, and over 30 take language courses at any given moment.

Formal training absorbs over 3.2 per cent of the payroll (about 100 million FF in 1990), and is managed by a staff of three. Annual and long-term (four-year) training plans are drawn up, on the basis of needs assessed in each production area. These plans are discussed with supervisors and approved by management. To the extent possible, individual requests for training are accommodated within the overall training. Preference is given to training programmes of short duration, and not for the acquisition of basic qualifications (such as CAPs or BTs, the French denomination for technical qualifications at the secondary school level or equivalent).

Probably more important than formal training are the informal mechanisms of learning through participation and exchange of ideas, two of which are highlighted below.

"Progress Groups" is the name given at Intelligent Pots to quality control groups. These informal groups meet under the leadership of

the supervisor. Special training exists to improve the capability of individuals to contribute to these meetings. These groups are expected - and encouraged - to present all types and kinds of suggestions and solutions. A review process is in place to evaluate the feasibility of the proposals. Solutions are either proposed by the Progress Group or, later on, by specialised task forces. A progress sheet can always be found in each production line, stating specific targets, the action underway, and the people responsible for the quality improvements being pursued at any given moment.

So far, there has been no preoccupation with monitoring the number and quality of suggestions and the acceptance rate. One of the reasons is the existence of other mechanisms of quality control and efficiency improvement. Nonetheless, the firm's management is convinced that the number and quality of the suggestions generated by those groups have been increasing over the years; the number of suggestions accepted is also believed to be increasing, and is currently estimated to be over 60 per cent.

A second informal mechanism of quality improvement is provided by the methods' technicians, responsible for upkeeping and introducing new innovations. These technicians systematically start their inquiries with the workers in charge of production. Moreover, since these same technicians are encouraged to take on posts as production supervisors or operators, they become very knowledgeable about the intricacies of the production process. When performing these interviews and observations, they frequently meet operators who were their former colleagues in the methods unit. All these factors make communications between staff and line more fluent and easy, and contribute to improving the productivity, quality and acceptability of new work technologies.

Even though it is impossible to measure, the formal and informal channels of technical communication between all the participants of the production process are probably the most used, most intensive, and most effective means of individual, group and organisational learning.

1. Incentives for learning

Learning seems to be the central business of Intelligent Pots. In order to produce pots and pans today, or intelligent pans for the domotised homes of tomorrow, Intelligent Pots invests, and heavily, in learning.

During our visit to Intelligent Pots we often asked about incentives: incentives for learning, incentives for training, incentives for contributing to quality improvement, incentives for productivity. It sounded as though the visitor was speaking a language strange to the organisation. The reason is simple. Intelligent Pots seems to have developed a built-in incentive system for people to learn - and that allows the entire organisation to learn.

First, the firm apparently managed to convince most of its staff that learning is important business. In this case, fear of losing the job was not an important negative motivator - staff have never been threatened and the firm has been hiring people steadily in the last 15 years. Example, emulation, or willingness to learn and to profit from training opportunities seems to be a better explanation. The potential to learn was there. It was the firm which developed, by changing organisational practices, the capacity of untapping whatever potential was locked in during the past.

Evidence of the interest of workers for training comes from a variety of sources. Voluntary participation in formal training activities is but one example. So far, the firm has never faced problems in filling its formal training courses. Individual requests for additional personal training have been systematically above the level the firm has been able to finance - or that it considers to be worth the investment.

Second, internal promotion has been a major motivator for mobility. Out of 15 supervisory job changes in the last two years, 14 were filled through internal promotion. Other promotion

and internal mobility mechanisms exist, as already mentioned, to encourage exchange of personnel between line and technical staff. Such promotions systematically and consistently signal the importance of acquiring new skills.

Third, and considering that the salary scale is already very compressed, the mechanism of participation in the financial results of the firm seems to act as an additional source of interest in the overall productivity, quality and image of the firm.

In addition to these fragmented explanations, it seems that at Intelligent Pots, learning, training, communicating, and participating in the production process reflect the overall managerial culture, and have become internalised as an integral part of the working process. Working and learning are no longer distinct activities.

2. Changes in recruitment practices

Intelligent Pots is a clear-cut example of a firm using tomorrow's technologies with today's workforce. Its personnel and training practices illustrate the transition within which modern industrial firms have to cope.

Even if hiring an entirely new workforce were possible, very few firms would have taken this road. For a number of reasons, firms prefer to upgrade their workforce and adjust it to the requirements of the changing times.

New recruitment policies, however, may reflect a firm's vision of the profile of the workforce of the future. At Intelligent Pots, recruitment practices have also changed over time. The firm is increasingly looking for higher levels of qualification. Mechanics with knowledge of electricity or electronics are preferred to conventional mechanics. Technicians with a diploma from a secondary (BTS) or a post-secondary (IUT) are now recruited for places previously held by people with a CAP (post-primary vocational training certificate) plus some job experience. The firm no longer has place for people without technical qualifications.

A major problem being encountered with the newly trained and highly qualified technicians and engineers is their lack of shop-floor experience and their orientation towards office - rather than production activities. The firm's policy is to involve new recruits in line functions directly related to the production process - before allowing them into a staff and technical position. Whether or not the firm is able to retain these clean office-bound recruits in shop-floor positions for a long time is a problem for the years to come.

The idea of hiring people with broader and higher levels of qualification is not only to help solve problems of the present, but to anticipate the problems and uncertainties of the future. Whether the working conditions, the learning opportunities provided and the challenges the firm can present will be enough to maintain these highly qualified staff is becoming a pressing item on the agenda of senior management. And this is not an exclusive problem for Intelligent Pots. It is probably the major challenge for firms that attempt to survive and to thrive in the world of modern manufacturing.

Annex I

Technology literacy curriculum at Avionics

OBJECTIVES

- Overview and direct exploration of the new technology environment
- Opportunity to engage in personalised learning experience
- Work through training group to understand changes inherent in the new technologies

CONTENTS

TOPICS	Sessions
Electronics	8
Automation	7
Informatics	7
Robotics	6
Numeric Control	7
Integrated Manufacturing	4
Communications	8
Total	47 x 3.5 = 164.5 Hours

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